Cooling Tower Measures

Statewide Codes & Standards Program

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under contract to PG&E/HMG

Scope of Study

- Three Measures:
  - Limitation of air-cooled chillers
  - Provision for cooling tower flow turndown
  - Limitation on use of centrifugal fans for cooling towers

Air-Cooled Limitation:
Issues

- Air-cooled systems are less expensive and less efficient than water-cooled systems
- Increased efficiency and cost of water-cooled systems may cause unintended market shift towards air-cooled applications

Air-Cooled Limitation:
First Costs

3 Climates representing a range of wet-bulb temperatures
3 plant sizes 200 tons, 400 tons & 600 tons

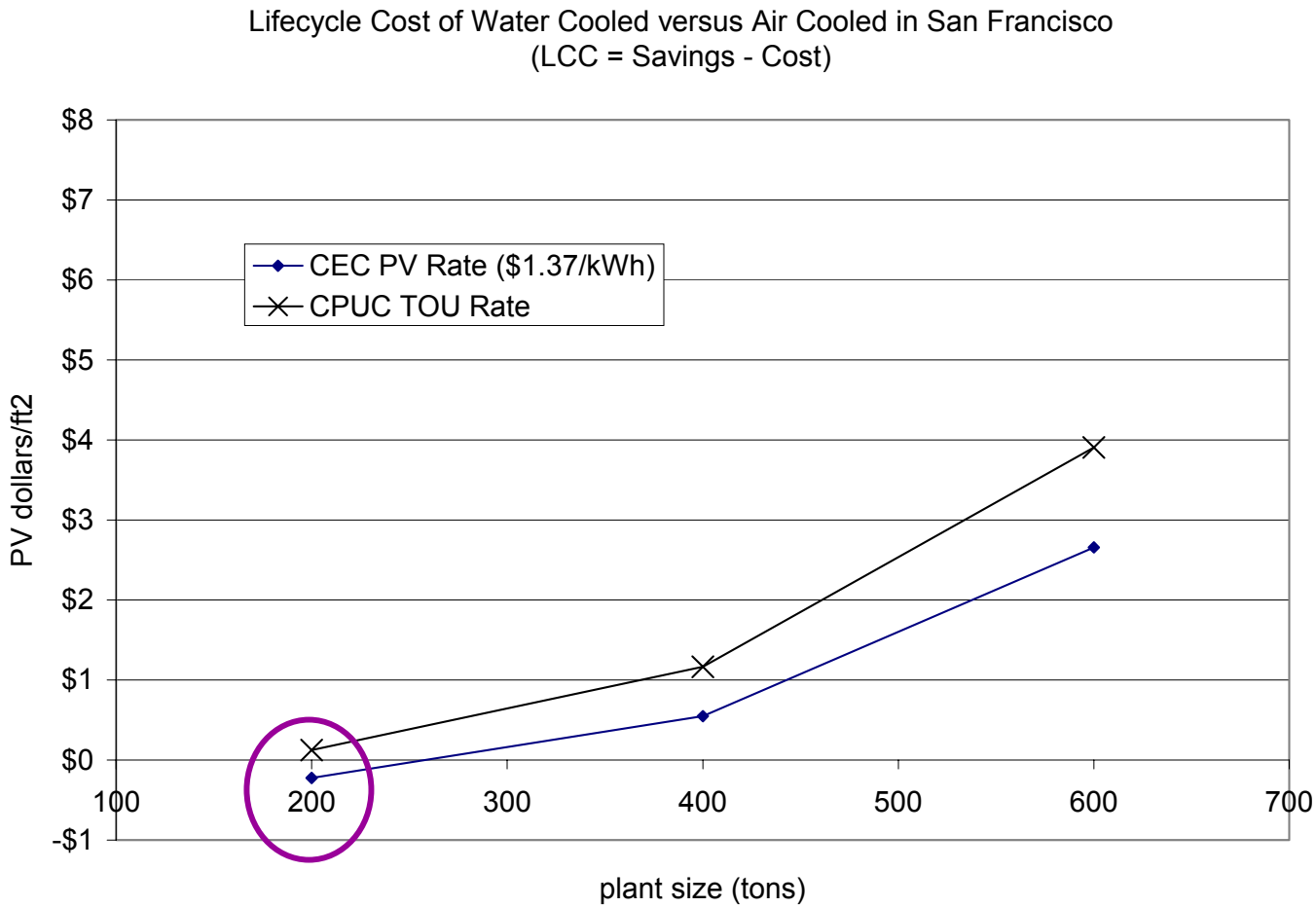
Air Cooled Assumptions	200 ton Plant	400 ton Plant	600 ton Plant	
num chillers	2	2	2	
cost/chiller	$ 37,668	$ 70,313	$ 100,286	data from Trane, Carrier, York
chiller cost	$ 75,336	$ 140,625	$ 200,572	
incremental screen wall length (ft)	30	40	50	estimate
screen wall cost ($/ft)	5	5	5	estimate
screen cost	$ 150	$ 200	$ 250	
Air cooled first cost	$ 75,486	$ 140,825	$ 200,822	
Incremental Cost (Water Minus Air)				
Incr. First cost - San Francisco	$ 82,236	$ 81,555	$ 159,765	
Incr. First cost - Long Beach	$ 79,411	$ 80,330	$ 152,640	
Incr. First cost - Fresno	$ 78,861	$ 79,055	$ 152,640	
Avg	$ 80,169	$ 80,313	$ 155,015	
Incr. Annual Cost	see Annual Cost above			

Air-Cooled Limitation:
Modeling Assumptions

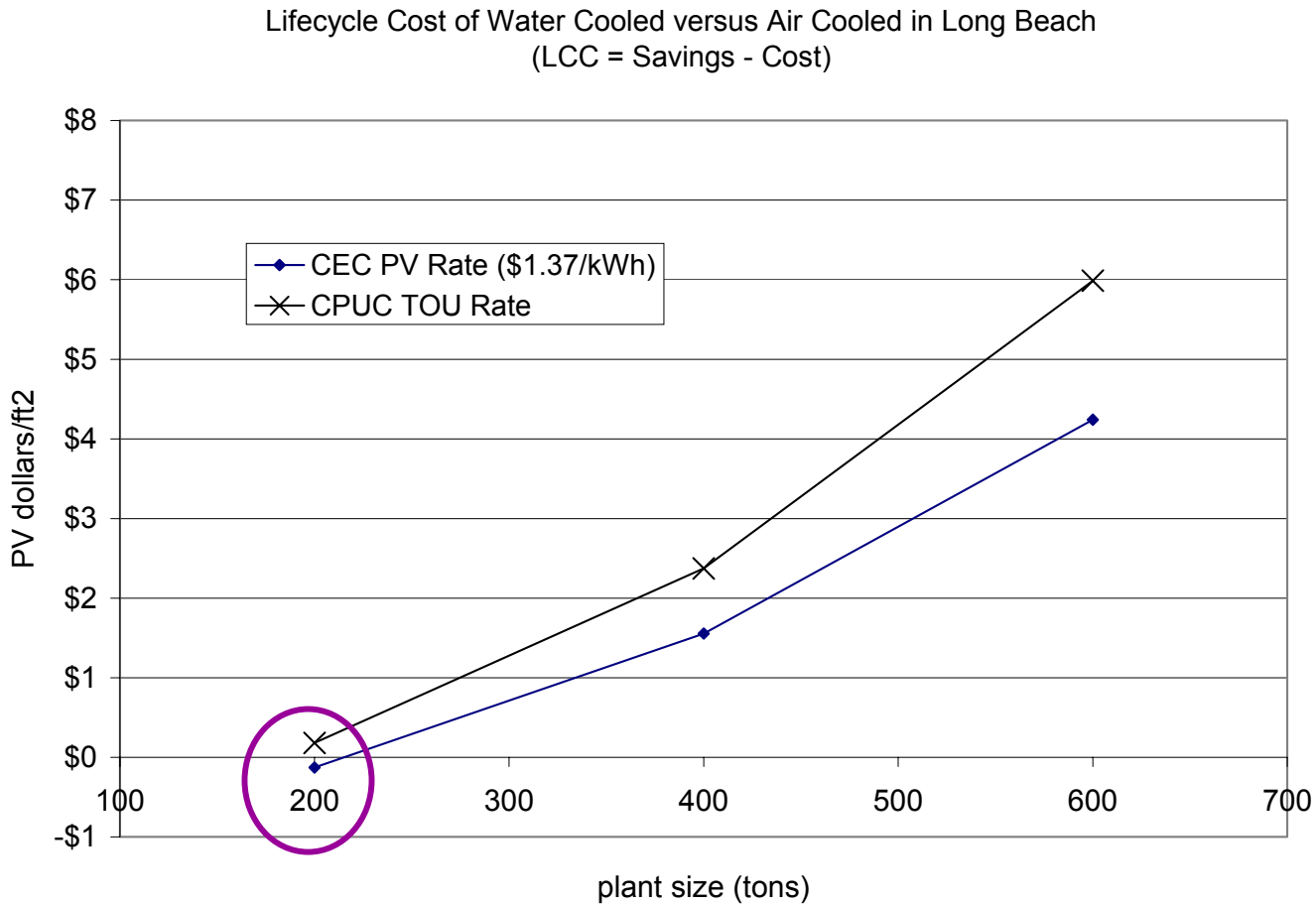
Water Cooled Modeling Assumptions		
chiller type and T-24 min efficiencies	200t = (2) 100t screw (4.45 COP = 0.2247 EIR, 4.50 IPLV)	
	400t = (2) 200t screw (4.90 COP = 0.204 EIR, 4.95 IPLV)	
	600t = (2) 300t centrif (6.10 COP = 0.1639 EIR, 6.10 IPLV)	
chiller curves	DOE-2 defaults for W.C. screw, centrif	
CW pump selection	GPMs from the CoolTools optimization, Head from EA and other designs	
chiller min unloading	0%	DOE-2 does not do a good job modeling start/stop losses
chiller HGB	15%	ACM min unload default is 10% centrif, Screw 15%
chiller staging	max out 1st before bringing on second	
Tower efficiency (EIR)	0.01	based on manufacturer's cost/performance data
CW approach	7 degree F	common practice
CW delta T	18	based on CoolTools optimization
CWST setpoint	fixed at design wb	

Air Cooled Modeling Assumptions		
chiller type	200t = (2) 100t screw	
	400t = (2) 200t screw	
	600t = (2) 300t screw	
chiller efficiency	T-24 min = 2.8 COP (0.357 EIR), 2.8 IPLV	
chiller compressor vs fan power split	93% compressor, 7% fan	Carrier catalog
compressor EIR	0.3333	
fan EIR	0.0245	
chiller curves	DOE-2 defaults	
Min Air temp	70	default
	Below this, control action is initiated to maintain this min temp.	
chiller min unloading	0%	DOE-2 does not do a good job modeling start/stop losses
chiller HGB	15%	ACM min unload default is 10% centrif, Screw 15%

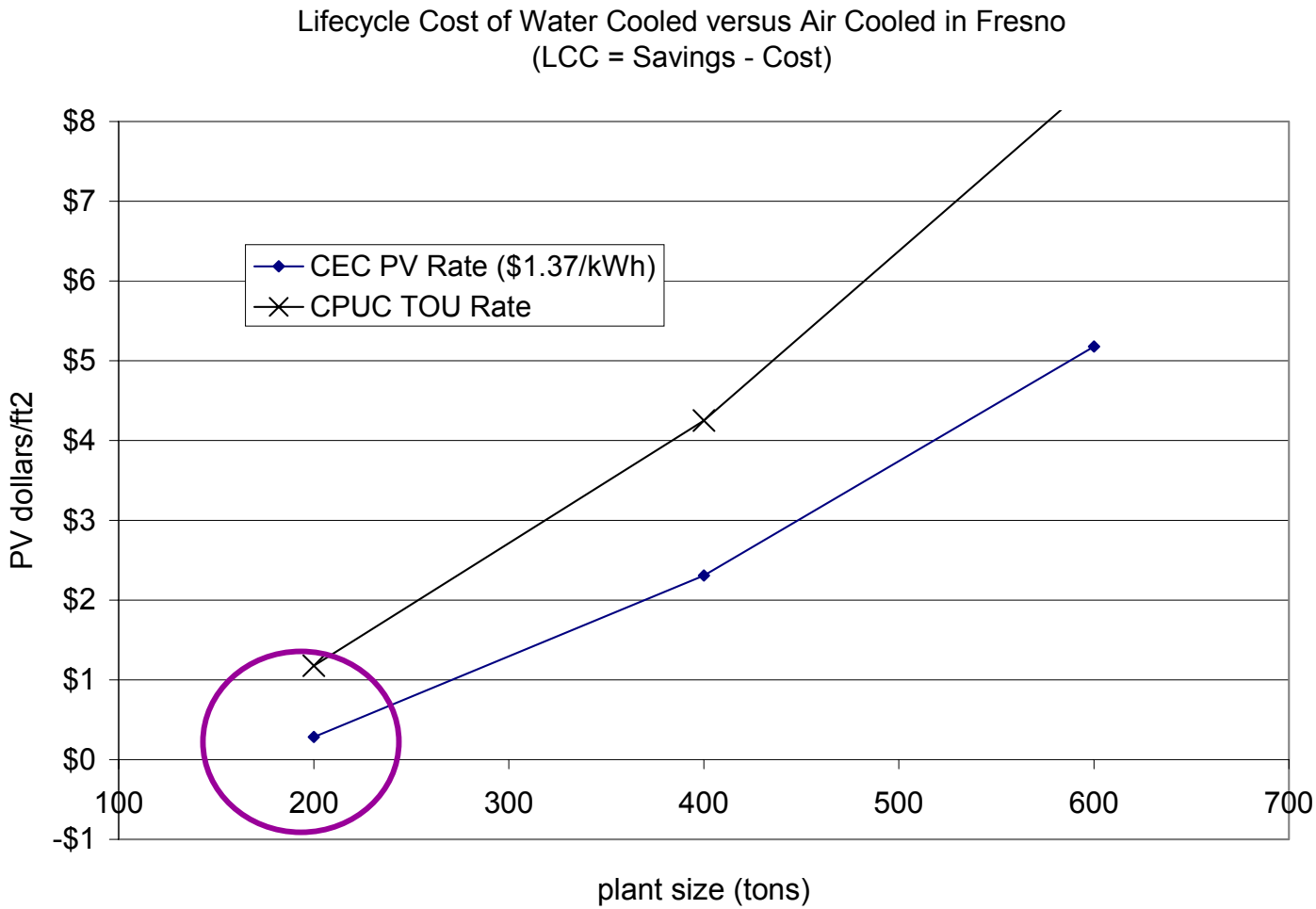
Air-Cooled Limitation:
Results (SF 84Tdb/65Twb)



Air-Cooled Limitation:
Results (Long Beach 97Tdb/70Twb)



Air-Cooled Limitation:
Results (Fresno 104Tdb/73Twb)

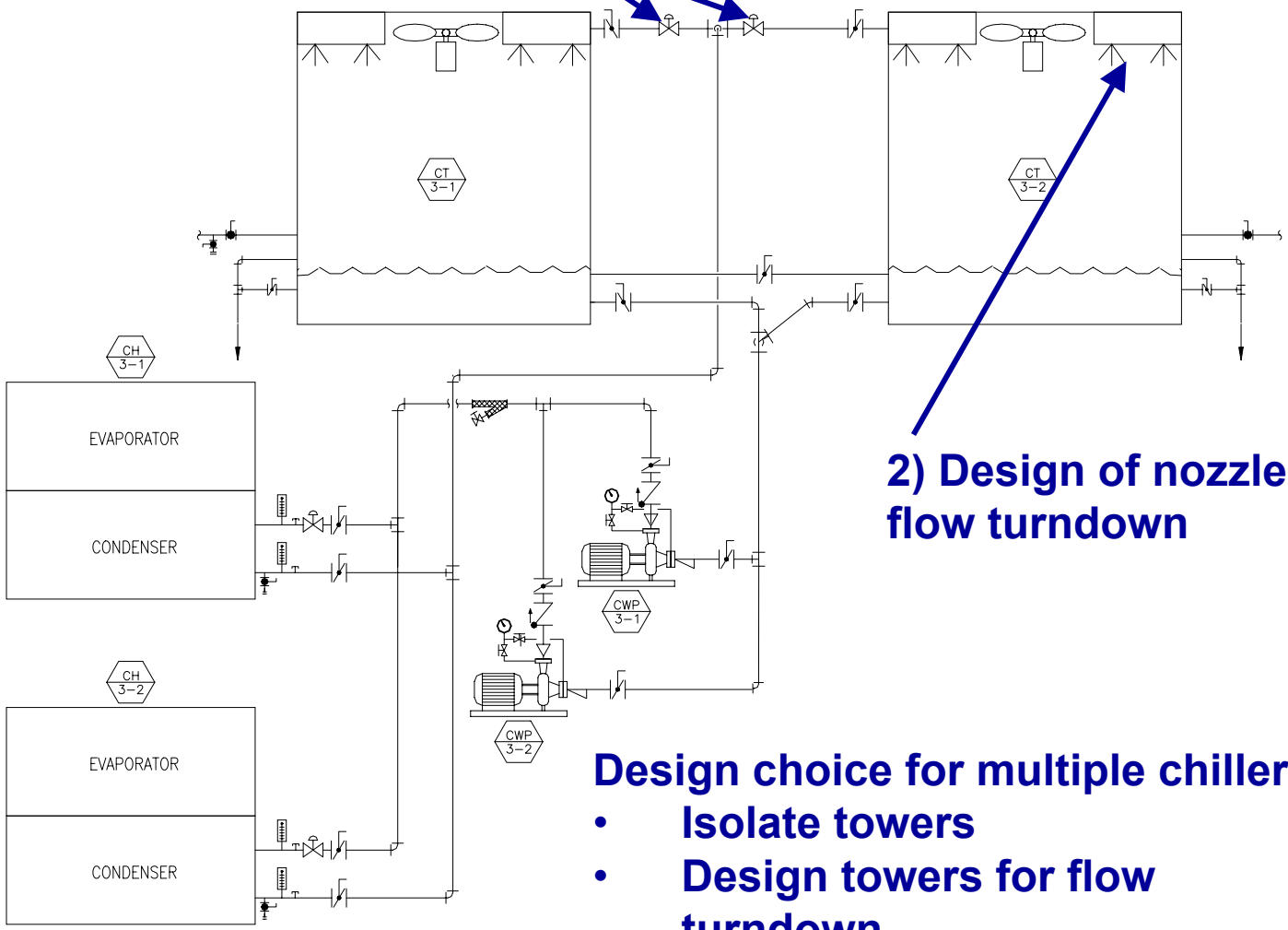


Air-Cooled Limitation:
Proposed New Prescriptive Requirement

- *Chilled water plants shall employ water-cooled chillers.*
- *Exceptions:*
  - *Air-cooled chillers may be installed up to a maximum total installed capacity of 300t*
  - *Where it can be demonstrated to the authority having jurisdiction that the water quality prohibits the use of water-cooled equipment.*

Cooling Tower Flow Turndown: Issue

1) Isolation valves



2) Design of nozzles for flow turndown

Design choice for multiple chiller plant:

- Isolate towers
- Design towers for flow turndown

Cooling Tower Flow Turndown: Analysis

- Turndown saves energy AND reduces first cost
- The tower can more efficiently reject heat with more cells operating (near cube law fan energy savings)
- 3:1 turndown cost ≤$500/cell
- Isolation control actuator costs ~$2,000/cell

Cooling Tower Flow Turndown:
Proposed New Prescriptive Requirement

- *Heat rejection units configured with multiple condenser water pumps shall be designed so that all cells can be run in parallel with the larger of the flow that's produced by the smallest pump or 33% the design flow.*

Centrifugal Fan Limitation:
Issues

- Low profile applications, centrifugal blow-through towers can be built lower than draw-through towers with propeller fans.
- Applications with high static pressure like towers that are sited in a well and require ducted inlet or outlet air. This is a legitimate issue.
- Noise sensitive applications. Propeller fan towers can handle the static of sound attenuation if required.

Centrifugal Fan Limitation: Analysis

- Centrifugal fan towers use ~ 2X the energy of propeller fan towers
- In large tower sizes (<300t) without sound attenuation on a centrifugal tower, propeller towers with attenuation cost less and are quieter.
- For larger tower sizes propeller towers are also available in a reduced height configuration

Centrifugal Fan Limitation:
Proposed New Prescriptive Requirement

- *Heat rejection units serving cooling loads 300t and greater shall use propeller fans in lieu of centrifugal blowers.*
- *Exceptions:*
  - *If heat rejection units is located indoors and requires external static pressure capability*
  - *If an acoustical engineer certifies that acceptable noise levels cannot be achieved with a propeller fan tower.*
  - *If the heat rejection units meets the energy efficiency requirement for propeller fan towers in Section 112, Table 1-C7.*

Questions